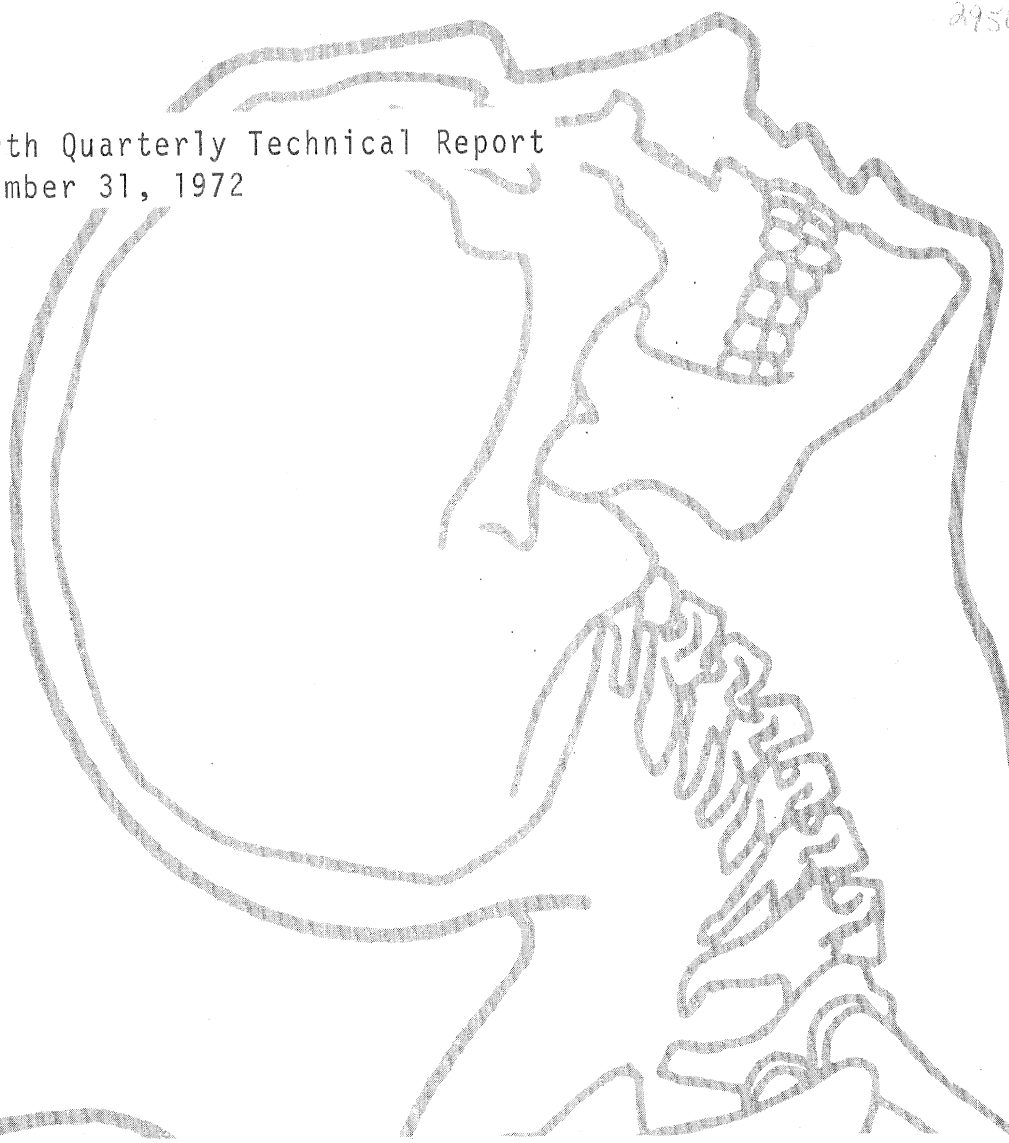
15

Fourth Quarterly Technical Report
December 31, 1972



Bioengineering Study of Basic Physical Measurements Related to Susceptibility to Cervical Hyperextension-Hyperflexion Injury

Richard G. Snyder
Don B. Chaffin
David R. Foust
Janet Baum

Highway Safety Research Institute
The University of Michigan
Ann Arbor, Michigan 48105

Prepared for
Insurance Institute for Highway Safety
Watergate Six Hundred
Washington, D.C. 20037

BIOENGINEERING STUDY OF BASIC PHYSICAL MEASUREMENTS RELATED TO SUSCEPTIBILITY TO CERVICAL HYPEREXTENSION-HYPERFLEXION INJURY

Fourth Quarterly Technical Report
December 31, 1972

TABLE OF CONTENTS

LEGEND

FIGURES

TABLES

SUMMARY

During this fourth reporting period, September 30 through December 31, the primary emphasis has been upon the collection of data, with concurrent data analysis. Some refinements of techniques are reported and in general the work is going smoothly with excellent results. The major serious problem remains that of obtaining data on all of the subjects specified in the experimental design within the time remaining for the data collection phase of the study. A brief summary of major task accomplishments during this period reflect the following progress:

1. A continuing search of the literature has resulted in acquisition of 300 additional references for a total to date of 2111 references cited. No new cervical motion studies, beyond the 23 reported earlier, have been located. An effort at accumulating foreign references was made during this period and a large proportion of the bibliography listed contains foreign references, indicating the international interest in this area.

2. The subject pool has been greatly expanded, with 250 medical questionnaires distributed to date to potential subjects, and 188 returned. Of these, 18 (13.9%) were rejected on a basis of medical history and 40 (30.5%) were rejected for other reasons in the 18-24 year age group. In the 35-44 year age group, 11 of 57 questionnaires returned (19.3%) were rejected for medical reasons, and 2 for other reasons, for an overall rejection rate of 23.2% for that group. During the next reporting period an emphasis will be placed on obtaining subjects in the third age group and a higher rejection rate is anticipated.

3. Forty-two additional subjects have been X-rayed, for a total of 85 sets of radiological data. Of these 80 were useful; five subjects to date being rejected on a basis of clinical review of the X-ray films. Several

changes of procedures described in the Third Quarterly Report have been continued with excellent reproducibility: the use of a "dropped-shoulders" lateral view, replacing the "soft-seat" view; the use of a metal reference rod attached to a headband to determine a reliable neutral position head angle; and the use of a reference line tangent to the skull to obtain reliable measurement of ranges of motion.

4. 77 sets of X-rays have now been analyzed for neutral head postion, flexion, extension, and range of motion. Average range of motion for 40 females (26 young, 14 middle aged) measured from X-rays is 133.8°, and for 30 males (26 young, 4 middle aged) is 142.1°.

5. Photogrammetry has been completed for 76 subjects, with analysis of 70 of these. Use of high-contrast markers has proven a more reliable indicator of head position than the headband reference-rod arrangement previously used.

6. Anthropometry has been obtained from a total of 52 subjects to date, with information from 48 of the 52 coded and keypunched. A comparison between the subject population and the overall U.S. population for stature and erect sitting height measures demonstrates excellent correlation, and indicates that the population so far is representative.

7. Reaction time measurements for 40 additional subjects were taken during this quarter, for a total of 47 to date. Sample reaction times have been hand-analyzed from strip-chart records obtained from 20 female and 15 male subjects, and results show an average of 50 to 90 msec for both neck flexors and neck extensors. Several equipment refinements have increased efficiency and accuracy of data-taking.

8. Neck muscle strength measurements have been completed for a total of 47 subjects, and all data analyzed for 42 of these. Results indicate

that the neck extensors are stronger than the neck flexors in both sexes. In the current period 40 subjects were tested, resulting in 80 sets of strength tests. Females ranged from a low of 7.3 lbs. to a high of 45.5 lbs., while males ranged from 11.4 lbs. to 63.5 lbs.

9. The debugging process was completed for automated data analysis. Complete data were analyzed for 11 subjects and required 12-14 minutes each, and it is estimated that only 50 hours time will be required for initial digitalization and analysis of data from the entire projected subject pool. Two problems with the real-time data summary produced on the line printer are outlined.

I. INTRODUCTION

Neck injuries to motor vehicle occupants are a common consequence of rear-end collisions. Such trauma has been characterized as "whiplash" or hyperextension-hyperflexion injuries. However, recent field and clinical investigations indicate that there is a significant preponderance of "whiplash" symptoms among females. Little information is known concerning variation in head mass or center of gravity of the seated occupant or variation of neck muscle strength as related to age, sex, and physique differences, and no previous study has related variation in neck muscle response time to external acceleration stimulus. Such information would appear to be of basic importance in consideration of sensitivity to hyperextension-hyperflexion injury.

The basic objective of this study is to determine the range of physical variation in function and structure of the human neck, with variables of age, sex, and stature, as a basis for improved head protection design in vehicular occupant hyperextension-hyperflexion accidents. Specific tests and measurements are being conducted to result in several major types of information relating to the range of physical and sexual variation of the neck in a representative U.S. population. Neck measurements to be determined include anthropometry, radiography, photogrammetry, muscle strength, voluntary range of extension and flexion cervical motion, and muscle response time. Mathematical modeling is being used to predict dynamic sensitivity to changes in the parameters developed.

Technical accomplishments during the fourth 90-day period of this investigation are reviewed in the following report. Emphasis during this period has been upon data acquisition and initial data analysis.

II. TASK PROGRESS

1. Literature Survey

Efforts continued during this quarter to locate additional references related to the neck and its characteristics. The general body of literature is considerable, although relatively few studies directly pertinent have been located to date.

The bibliography format used in previous reports has been continued. Additional references located during this period are organized into five general categories: motion/mobility; mechanisms of injury; anatomy/radiography; experimental strength/stress; and injuries/fractures. We continue to find the bulk of references related to clinical reports to be of interest primarily because they emphasize the widespread concern with cervical injuries and their treatment.

The bibliography has been enlarged by nearly 300 additional references during this reporting period, and now consists of 2111 references. In keeping with past practice, we have included only new acquisitions in the bibliography for this report. The bibliographies from each quarterly report will be combined and included in the final report.

Effort during this quarter was placed on the international aspects of the cervical problem. Hence, foreign language references constitute a majority of the bibliography. The worldwide distribution of articles (Japanese, German, Russian, Italian, African, etc.) reflects a high level of interest in the neck and its characteristics throughout the medical profession.

Although an additional 25 references related to the category "motion/mobility" were located, no new or recently-reported studies were found. Most of the articles are concerned either with subjects whose normal mobil-

ity has become impaired, with total spinal mobility, or with motions other than in the sagittal plane. Consequently, the number of normal cervical motion studies remains at 23; these have been reported previously.

At this time, the references in each category of the bibliography are as follows: motion/mobility, 25 new references, for a total to date of 207; mechanisms of injury, eleven acquisitions which bring the total to 102; anatomy/radiography, an increase of 55 to a total of 336 reports; experimental strength and stress, 22 additional references for a total of 218; and clinical reports of injuries and fractures, an increase of 180 and a current total of 1248.

2. Subject Pool

The size of the subject pool expanded considerably during this quarter, as a major effort was undertaken to complete acquisition of subjects in the 18-24 age group and also to fill the 35-44 age group.

We had anticipated that it might be difficult to locate subjects for the 35-44 age group, since they do not tend to congregate in easily accessible groups (such as college students in dormatories). We decided to advertise, and in early October, a classified ad was placed in the local newspaper. The response was much larger than we expected - some 75 phone inquiries were answered. The largest number of respondents were females, and in many cases we were able to enlist their husbands at the same time. It appears that enough potential subjects were recruited from the ad to fill all female size classifications in the age group, as well as the male medium and tall sizes.

Locating short males and females in both age groups has been a continuing problem, but extensive word-of-mouth and bulletin board canvassing is having a positive effect. We now have sufficient "leads" or questionnaires on hand to fill all but the short male category in the 35-44 age group.

No major effort to enlist the elderly age group has yet been made, but several initial inquiries through contacts at local senior citizens' retirement centers have brought a positive response. Much of our subject pool activity in the next quarter will be directed at locating subjects in the 65-74 age group. While there are at least five non-convalescent retirement centers in the area, we may have a considerable problem with health questionnaire rejections. Depending on how acute this problem becomes, it may be necessary to increase the age range by five years to include 60-65 year-olds. Expansion of the age range will be undertaken only if insufficient

numbers of subjects are located in the preferred age group.

The current status of the subject pool may be summarized as follows. Approximately 250 questionnaires have either been distributed to groups or mailed out with return envelopes. Where possible, the name of a potential subject is obtained before a questionnaire is given out. Of those potential subjects thus identified, we currently have 30 questionnaires out but not returned (consisting of 5 from the young age group, 20 middle age, 2 elderly and 3 of unknown age). Since the start of the study, some 188 questionnaires have been returned. Of these, 131 fit into the young age group and 57 fit the middle age group. Questionnaires rejected on the basis of health history alone totalled 18 for the young age group (a rejection rate of 13.9%). When medical history rejections are combined with 40 questionnaires unusable for other reasons (moved, too old, category filled, etc.), a total of 58 responses, or 44.3% were unusable in the young age group. The medical rejection rate for the middle age group so far is 19.3% (11 of 57 questionnaires returned). This rate is slightly higher than that for the younger age group, which is to be expected. However, due to the more discriminate canvassing of subjects in this group (the newspaper ad) only 2 questionnaires have been unusable for other than medical reasons. Therefore the total rejection rate for subjects in this middle age group is 23.2%. No rejection rate for elderly subjects can be established until active recruiting begins in that group.

On the basis of subjects already measured plus approved questionnaires on hand, all subjects needed to fill all of the size categories in the young age group have been located (except for the short male group, which lacks 2 subjects). In the middle age group, all female categories plus that of tall

males are in hand, while short and medium-sized men remain largely unlocated. Follow-up of unreturned questionnaires is beginning and will hopefully aid in filling out these categories.

It will become apparent as this report is reviewed that our previously stated goal of running 10 new subjects per week during the quarter was not achieved. While 42 subjects were X-rayed and testing was completed on 40 subjects, these were far fewer than we had expected to process. Several factors were involved in causing this gap, but the chief problem was the inherent difficulty of scheduling human subjects. Despite the fact that we maintain a large pool of "available" subjects, it was not uncommon to have to place 5 or 10 phone calls to schedule one subject. The holiday period also had a major impact, making it difficult to schedule subjects in the week before Thanksgiving and Christmas. For example, in the week before Thanksgiving, 5 of 6 scheduled subjects either cancelled at the last minute or simply failed to appear. While we were able to reschedule most cancellations, the time period originally intended for testing that subject usually went unfilled. Scheduling difficulties, cancellations, minor equipment maintenance problems (which increase with heavier use), and the fact that our primary laboratory assistant is showing an allergy to something in the lab have all contributed to not being able to measure as many subjects as we would have preferred. The corrective actions being implemented to counter these problems are described in Section III of this report.

3. Radiography

The two changes in X-ray procedures described in the Third Quarterly Report have been in use during this quarter and have proven effective. The use of the metal reference rod attached to a headband provides a reliable neutral position head angle, and the reference line tangent to the skull (as previously described) is reliable in measuring ranges of motion. The use of a "dropped-shoulders" lateral view (instead of the "soft-seat" view) has been helpful in clinical evaluation of the cervical spine X-rays, since the C-7 (and sometimes T-1) vertebrae are shown more clearly with the shoulders lowered. We continue to analyze three X-rays for range-of-motion: hard seat neutral, hard seat flexion, and hard seat extension.

During the quarter, the X-ray (and photogrammetry) portions of the study were completed for forty additional subjects. A total of 85 sets of X-rays have been taken to date. Of these, 80 sets provide useful range-of-motion data. Five subjects to date have been rejected on the basis of clinical review of the X-rays. Three of those were reported previously. During this period, two subjects could not continue: one young male had a motorcycle accident history (though X-rays were inconclusive) and one 36-year-old female who showed arthritic degeneration abnormal for her age. In addition, five subjects who were X-rayed are no longer available to finish the study. Their results will not be included in the final analysis, even though the X-rays have been analyzed for range-of-motion.

The approved, usable X-rays on hand at the end of the quarter are broken down by category as shown in Table I. No X-rays of elderly subjects have been taken.

TABLE I

APPROVED X-RAYS BY SUBJECT CATEGORY

Sex/Age	Short	Medium	Tall
Females, 18 - 24	6	8	12
Males, 18 - 24	5	11	12
Females, 35 - 44	4	4	8
Males, 35 - 44	0	1	4

Total 75

To aid in data analysis and reporting, a coding system has been developed to put all X-ray and photogrammetry range of motion data for a given subject onto two punched cards for computerized statistical analysis. The coding method is compatible with programs contained in the University of Michigan Statistical Research Laboratory library. It will be possible in the future to analyze our range-of-motion data using already-existing computer programs.

A total of 77 sets of X-rays have been analyzed for neutral head position, flexion, extension, and range-of-motion. The data from seventy sets have been coded and keypunched. For this report, only total range-of-motion was analyzed, with the following results. For 40 females (26 young, 14 middle age) the average range of motion measured from X-rays is 133.8 degrees, with a standard deviation of 20.8 degrees. The average range-of-motion for 30 males (26 young, 4 middle age) is 142.1 degrees, with 15.9 degrees standard deviation. Taken together, the 70 subjects analyzed to date averaged 137.4 degrees range-of-motion (standard deviation 19.2 degrees). This range is in fundamental agreement with the 130 degrees average compiled from 20 literature sources.

4. Photogrammetry

Data acquisition in the photogrammetry phase of the study progressed smoothly throughout the quarter. Use of high-contrast markers taped directly to the skin at the nasion and tragion positions has proven to be a more reliable indicator of head position than did the headband and reference rod arrangement used previously. Otherwise, procedures remain unchanged - the neutral, flexion, and extension positions are each being photographed three times, in sequence. Efforts to limit shoulder and upper torso motion by closely observing a shoulder bullseye have been successful. Subjects are asked to repeat the position if the shoulders move. This allows accurate range-of-motion measurement of the head and neck only without the necessity of seat belts or torso restraints.

As noted in the previous section, photographic range-of-motion data are coded onto two punched cards for computerized statistical analysis.

To date, a total of 76 subjects have been photographed. The photographs from seventy subjects have been analyzed, coded and keypunched. Range-of-motion analysis from the same forty women and thirty men as reported in the radiography section is presented in Table II. Note that the previously-described X-ray analysis is repeated in Table II. The average range-of-motion measured for these subjects is extremely consistent. This supports the preliminary conclusion reached earlier, that subjects exhibit a high degree of repeatability in their individual ranges-of-motion. The large standard deviations attained continue to indicate large variations in mobility between subjects.

TABLE II

RANGE-OF-MOTION ANALYSIS

One X-ray sequence and three photographic sequences

SUBJECTS	TOTAL RANGE OF MOTION, degrees							
	X-RAY		PHOTO I		PHOTO II		PHOTO III	
	mean	std dev	mean	std dev	mean	std dev	mean	std dev
40 FEMALES	133.8	20.8	132.8	15.6	136.0	16.3	136.4	15.2
30 MALES	142.1	15.9	136.5	14.4	137.7	11.5	139.4	12.1
70 SUBJECTS	137.4	19.2	134.4	15.1	136.7	14.4	137.7	13.8

5. Anthropometry

All subject anthropometry obtained this quarter was taken using the 48 measures and the sequence described in the Third Quarterly Report. The procedure is refined and rapid; total time needed to mark the subject and take the measures averages less than twenty minutes. All measurements are taken by the same individual to avoid inter-measurer errors.

A system was devised during the quarter to code anthropometry measures onto four punched cards. As with the range-of-motion data, anthropometry may then be analyzed using existing University of Michigan Statistical Lab computer programs.

Anthropometry has been obtained from a total of 52 subjects to date, and 48 of the 52 subjects have been coded and keypunched.

A limited analysis of selected measures has been completed. Stature and erect sitting height were analyzed for comparison with other populations, and posterior neck length, superior and inferior neck circumference, and head circumference were analyzed for sexual and size comparisons. It was found that males were larger on the average than females in all measures. Also, with the exception of posterior neck length, it was generally true that the rank order of other measures correlates exactly with stature: i.e., the taller person has the larger head and neck. Posterior neck length tended to be random among women and not correlated to stature.

A preliminary comparison of the study population with the U.S. population upon which our size criteria were based reveals some encouraging results. The 50th percentile (non-weighted average) for the study population compares very favorably with the 50th percentile of the U.S. population in the same age group. Similar results were obtained when both stature and

erect sitting height were compared. These results are illustrated in Table III. While it is true that the study population averages are based on very limited numbers of subjects, there is a definite indication that a random, representative U.S. population is indeed being recruited for the study.

TABLE III

INTERIM COMPARISON OF POPULATION MEASURES

Stature and Erect Sitting Height

SEX	AGE	STATURE, in.		ERECT SITTING HEIGHT, in.	
		Study Pop.	U.S. Pop.*	Study Pop.	U.S. Pop.*
FEMALES	18 - 24	64.4	63.9	34.1	33.7
FEMALES	35 - 44	63.6	63.4	33.7	33.7
MALES	18 - 24	68.7	68.6	35.8	35.9

* U.S. Population figures are 50th percentile figures for the indicated age group, as reported in National Health Survey, Weight, Height and Selected Body Dimensions of Adults: United States, 1960-62, Public Health Service. This is the study upon which our subject size selection criteria were based.

6. Reaction Time Measurements

The reliable measurement of reaction time remains the most demanding portion of the testing program. Generation of a signal sufficiently strong to be analyzed by computer continues to be a difficult task. Several subjects have been encountered who have had inherently "stiff" necks (especially tall men of average or heavy build). Even at the maximum allowable acceleration of one G, these few subjects have had virtually no muscle response. Fortunately, these are the exception, not the rule, and should not adversely affect the overall project results. It should be noted that even if a computer-analyzable signal is not obtained, enough of a change occurs in the EMG signal monitored with a strip-chart recorder to allow hand analysis of the test.

No new technical problems arose during the reporting period, and several minor continuing problems were resolved.

The problem of low EMG signal strength from the splenius capitis and semispinalis muscles in the back of the neck was solved by using electrode placements recommended by Davis.* The electrodes are placed specified distances from the palpated spine of the second cervical vertebra. We have found this landmark easy to locate and measure from in the great majority of subjects, especially since we have a lateral X-ray of each subject available for reference. The only drawback to this placement technique is that the superior of the two electrodes lies on or slightly above the hairline at the nape of the neck. Fortunately, most subjects tested to date are wearing the currently popular long hair styles, and we have had little problem in obtaining permission to trim away enough hair to allow proper electrode

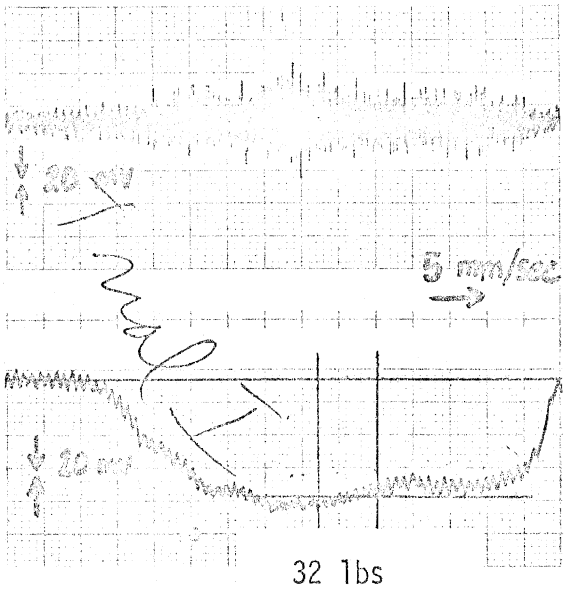
*Davis, J.F., Manual of Surface Electromyography, WADC TR 59-184, Wright Patterson AFB, Ohio, December 1959, p 22-23.

placement and good adhesion.

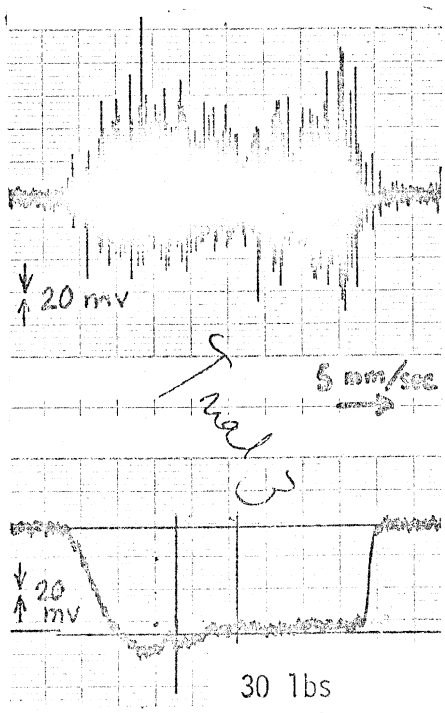
The effect of the new electrode placement on signal strength is illustrated in Figure 1. The recordings are strength tests of two tall women who developed approximately the same strength. The two recordings are directly comparable, and the large increase in signal strength is evident.

Efforts have also been successful during this quarter to reduce data losses to a minimum. The improvement in electrode placement has been the most significant advancement, but other techniques have also been helpful. For example, reaction time tests are very closely monitored. In most cases, a strip-chart record of the EMG and acceleration signals is taken from the tape recorder immediately after the test is run. In this regard, we have found that there is sufficient time to turn on the strip-chart recorder between the time the weight reaches the end of its travel and the time the recorded tape passes over the playback heads. This technique provides a check of the primary data channels virtually simultaneously with the running of the test. The edit feature in the control channel circuitry makes it possible to edit any test which does not produce measurable reactions. This real time check allows us to immediately increase weight drop distances and rerun a test. We are being persistent in rerunning tests until three analyzable reaction times are measured. Data losses, at least for the primary muscle group being tested, are now at a minimum.

Several equipment refinements described in the previous report were completed early in this quarter and have increased data-taking efficiency and accuracy. Figure 2 illustrates the work area used for controlling reaction time and strength testing. The tape recorder is mounted on a mobile cart with locking wheels. It is thus isolated from table vibrations which have in the past caused baseline shifts in recorded signals. The recorder



Subj FBZ-02 Tested 11-3-72
Test #1850-SE Trial I



Subj FAZ-02 Tested 12-8-72
Test #1340-SE Trail III

FIGURE 1

COMPARISON OF EMG SIGNALS FROM SPLENIUS CAPITIS MUSCLES

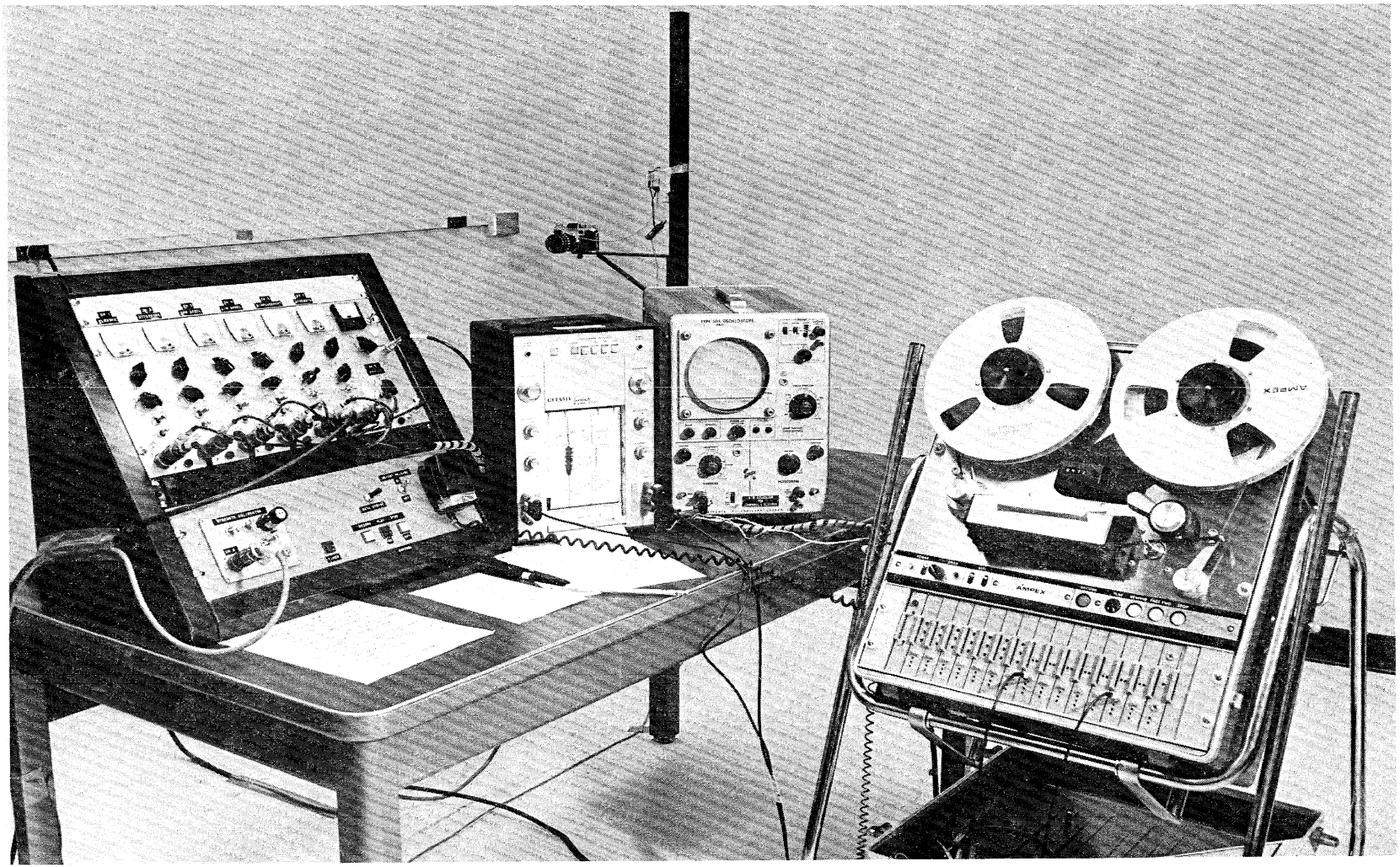


FIGURE 2

TEST CONTROLLER'S WORK AREA

This equipment is used to control, monitor, and record reaction time and strength testing activities. The equipment includes (from Right): the 7-channel Ampex recorder/reproducer, mounted on a cart for easy transportation to the computer which analyzes the data; an oscilloscope, used to monitor muscle reaction; a Brush strip-chart recorder, used to obtain data-check records of the tape recorded signal; and the monitor console, used to monitor and control the test sequence.

is now controlled remotely from a monitor panel in front of the test controller. To run a reaction time test, the controller observes the EMG from the primary muscle group in the oscilloscope. When the subject is relaxed, the controller turns on the tape recorder, releases the weight and watches for the muscle reaction in the CRO. If he is doubtful of signal strength or quality, he obtains a strip-chart record immediately from the playback section of the recorder. All controls are within easy reach and the progression through the reaction time and strength testing sequences moves very smoothly.

Figure 3 shows the monitor console in detail. When the controller faces the console, he may also observe the subject at a glance. All of the testing functions are handled from the console, which features gain controls for all channels, a monitor switch to allow monitoring of any one channel, a control channel test level selector, the strength calibrator for determining muscle strength, a microphone for voice track recording, off-on controls for the tape recorder and control channel (same switch works both), and weight release/control channel data strobe switches. The monitor console has proven to be highly reliable in daily use.

Forty additional subjects were tested for reaction time during this quarter. Valid reaction time data have now been collected from 47 subjects. Head accelerations now achieved are consistently greater than 0.5 G, and usually are in the 0.75 to 1.0 G range. This produces a distinct increase in muscle activity in all but a few isolated instances. Head displacements generally range from one to three inches.

Sample reaction times have been hand-analyzed from strip-chart records obtained from 20 female and 15 male subjects. The results obtained thus far show a range of 50 to 90 msec for both neck flexors and neck extensors,

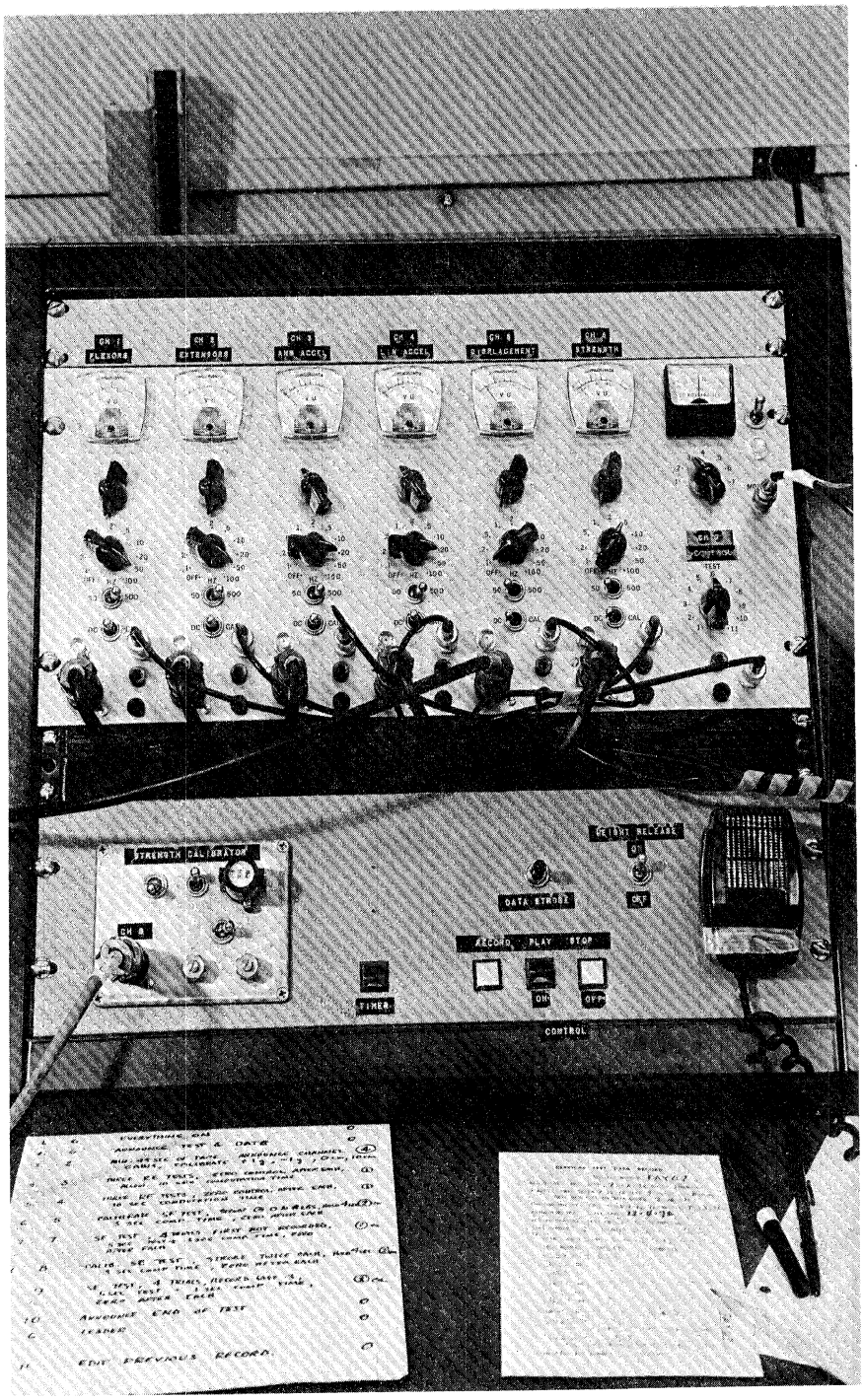


FIGURE 3

DETAIL VIEW OF MONITOR CONSOLE

This unit controls all recording and test functions. It includes channel gain controls, a control channel test selector, a meter which can be used to monitor any channel, the strength calibrator, the tape recorder microphone, off/on controls for the tape recorder and control channel, a weight release switch, and a silent data strobe switch which puts control signals on the tape (and releases the weight for reaction time tests if the weight release switch is "on").

but are of such great variability that it would be misleading to present them in more detail at this time. Additional subjects and more refined analysis techniques will provide more useful results in the near future.

7. Neck Muscle Strength Measurements

Neck strength measurement procedures in use during this quarter have not changed from those described in previous reports, except for the introduction of a "learning" exertion. The subject produces one unrecorded short-term exertion with neck flexors and neck extensors prior to recording the three maximum strength trials. This allows the subject to experience the sensations produced by the exertion and has probably reduced the degree of learning trend seen in the three strength trials.

Strength testing has been completed with a total of 47 subjects to date. All strength test data have been analyzed from 42 of these subjects: 24 females and 18 males. The results, which are summarized in Table IV, show first that the neck extensors are stronger than the neck flexors in both men and women and second that men are stronger, on the average, than women. These results are not unexpected, though individual differences resulted in some women being stronger than men of similar size and weight. It is also interesting to note the larger degree of variability among men than women.

The effect of instituting a "learning" exertion was reflected when individual results were examined. Two learning trends were noted in twelve observations during the previous reporting period (6 subjects, each with flexor and extensor tests), for a trend percentage of 16.7%. In the current period, 40 subjects were tested, with 80 sets of strength tests resulting. Of these 80 sets of three trials each, only seven, or 8.8% exhibited trends. A majority of the trends occur during extension tests, which is probably due to body bracing being achieved through the spine and legs with successive tests. Also, some self-competition has been noted in trend situations. However, most subjects were consistent in the strength achieved under maximum exertion conditions. (22 of 24 women and 14 of 18 men exhibited less

TABLE IV

SUMMARY OF STRENGTH TEST RESULTS

SUBJECTS	MUSCLES	1.6 SECOND* MEAN STRENGTH (Pounds) TRIAL I		TRIAL II		TRIAL III	
		MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
24 FEMALES (16 young, 8 middle age)	Flexors	17.65	5.63	17.77	6.39	17.78	6.75
	Extensors	26.82	6.56	27.01	7.31	27.44	7.50
18 MALES (17 young, 1 middle age)	Flexors	32.55	11.02	32.87	11.46	31.57	9.80
	Extensors	37.35	9.55	39.87	10.15	42.00	8.87

*Strength test results were averaged over 1.6 seconds to allow comparison with computer analysis. Computer memory limitations currently restrict signal averaging to 1.6 seconds.

than 10% coefficient of variation - std dev ÷ mean - in either flexor or extensor tests or both.) There is a great deal of variation between subjects, as indicated by the ranges of recorded strengths. Females ranged from a low of 7.3 pounds to a high of 45.5 pounds, and males from 11.4 pounds to 63.5 pounds.

8. Computerized Data Analysis

The major emphasis during this period was placed on data acquisition and specialized analysis other than with automated computer analysis. However, sufficient effort was devoted to the computer program to complete the debugging process. The program works very smoothly now, automatically converting analog tape-recorded signals into digital format, analyzing up to five data channels simultaneously, and delivering the information to both a digital tape unit and a line printer. The efficiency of the program was demonstrated by analyzing data from complete testing of eleven subjects. The analysis time consumed only 12-14 minutes per subject, and it was not necessary to stop either the recorder or the computer during the entire 2 1/2 hour period. At an average of less than fifteen minutes per subject, initial digitalization and analysis of data from the entire subject pool will require only about 50 hours. Statistical analysis of the digitized data will require additional computer time, but the initial processing of the vast amount of data collected during the reaction time and strength tests will be accomplished in a relatively short time period.

Two problems exist with the one-line data summary of each test which is produced on the line printer. First, due to the limited memory capability of the Hewlett-Packard mini-computer (8000 words of memory), it has not been possible to refine the one-line data summary with desired scaling and conversion factors. Therefore, the line printer summary does not reflect immediately-usable numbers (except for time values). However, a newly-acquired disk storage system and a planned increase in memory capability may relieve the problems of memory limitation to a large extent. In the meantime, the digitized tape will be used to produce more refined data.

The second data summary problem involves the establishment of accurate reaction time measurements. A statistical pairing technique with variable thresholds has been used. Some difficulty has been experienced with the earlier data in setting the thresholds to ignore background activity but still detect an increase in muscle activity. Additional trials with varying threshold levels will no doubt resolve the problem. Threshold setting should be more straightforward with later data, since more effort is now being expended to insure a large signal from the desired muscle response.

Some analysis results from the one-line data summary produced by the computer have been compared to those obtained by hand analysis of the data. Because of the threshold problem described above, the strip-chart values will continue to be reported until the threshold problem is resolved.

The computer analysis, however, has been verified as reliably accurate for strength test results. This verification was accomplished in two ways. First, the results of each individual strength test were compared - the computer results and those of strip-chart analysis. Sixty-five individual tests from the eleven subjects were compared. In only two cases did the computer and strip chart results differ by more than 1.9 pounds (two pounds is well within strip-chart measurement error since the signal was averaged by eye over a 1.6 second period). The average difference was 0.9 pounds. The second verification technique was one of logic. The data summary of each strength test consists of: (a) average signal strength of each of the EMG signals, and (b) a ratio of strength calibrator signals which can be converted into strength in pounds. Strength test results, strip chart records, and computer printouts were compared for several subjects. In every case, EMG signal size ranked in the same order as strength test results.

Also, the primary group of muscles exhibited logically larger strengths than did the secondary muscle group. For example, in a series of tests with subject FAZ-04, in which the extensor muscles were primary, the following computer results were obtained:

Extensor Muscle signal	Flexor Muscle signal	strength (lbs)
19	14	10.0
39	25	20.0
63	32	28.4
55	28	25.6
59	29	27.8

In this instance, muscle strength is directly reflected in muscle signal strength of both primary and secondary muscle groups. This may be interpreted as evidence of the accuracy and correct logic of the computerized analysis of strength data.

Some time will be devoted to additional computerized data analysis during the next quarter, with the intent of producing final product results directly from the computer for the parameters being measured. The threshold problem should be resolved soon, and reaction time data should be available in the near future.

III. WORK TO BE ACCOMPLISHED DURING THE NEXT REPORTING PERIOD, JANUARY 1 THROUGH MARCH 31.

Data acquisition will receive the major emphasis during the coming 3-month period. Measurements of subjects from the oldest (65-74 year) group will be initiated, and in January an attempt will be made to have a backlog of all required subjects' medical questionnaires completed and approved. Subject data acquisition continues to be our major problem. Projecting, in order to obtain all data on all 180 subjects called for in the experimental design will require radiography on 100, photogrammetry on 106, anthropometry on 128, strength data on 133, and reaction time response data on 133 subjects. It is extremely doubtful that more than a total of 60 additional subjects can be completed at the present rate of acquisition. To increase this, we have added the month of April to our data acquisition time, are attempting to find "backup" subjects who can be called upon on short notice to fill in when cancellations occur, have drawn upon additional technician assistance, and will continue to attempt to schedule seven days a week if necessary, since often subjects are not available until evening or weekends. Public Health officials have predicted that, in the month of January, the "London Flu" may be expected to affect 50% of Michigan residents, and if so, may also cause serious disruption in our future scheduling. In view of this, some alteration of our experimental design may have to be considered or other alternatives considered. Data analysis by computer will continue. No further mathematical modeling will be initiated until April.

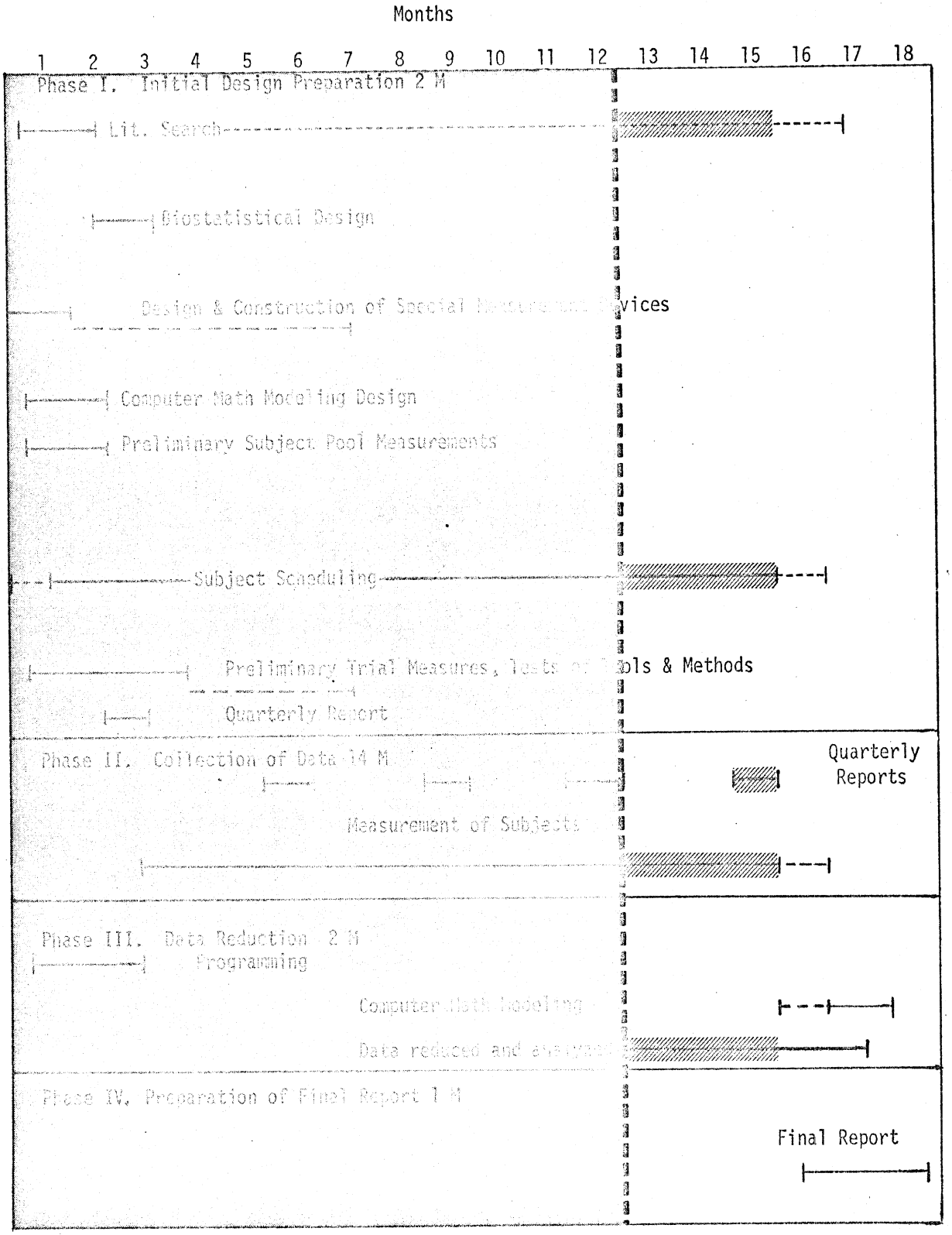
Experience to date indicated that we can reasonably expect to complete testing on at least 60 more subjects during the quarter. The addition of thirty more subjects in April and the fifty already completed brings the total to 140, rather than the 180 originally intended. At this point, 140 subjects can be considered the minimum data base attainable, with 160 the

maximum that could feasibly be completed by the end of April.

The schedule of projected activities through the next quarter and to the end of the program is reflected in Table V.

TABLE V

PROGRAM SCHEDULE



Indicates activities projected for Period 1 Jan. - 31 Mar.

Portion of Program completed.

IV. BIBLIOGRAPHY

1. MOTION/MOBILITY

Balzar, M. "[Point Evaluation of the Extent of Movement in Joints and in the Spine]" Acta Chir Orthop Traum Cech 33:68-75, February 1966. (Cz)

Berthoz, A., et al. "[Biomechanical and Electromyographic Study of Head Movements in Humans Subjected to Low Frequency Vibrations]" J. Physiol (Paris) 57:556, September-October 1965. (Fr)

Boehm, K. "[Description of an Apparatus for Measurement of the Mobility of the Lumbar Vertebrae]" Z Orthop 92:125-127, 1959. (Ger)

Bauer, J., et al. "[Objective Evaluation of Polyelektromyographic Methods for Kineziological Examination of the Spine]" Cesk Neurol 27:224-8, July 1964. (Cz)

Cappellin, M. "[Ascertaining Limits of Spinal Movement]" Minerva Med. 74: 17-21, 1954. (Ital)

Draper, G.W. "Altered Vertebral Mechanics in the Atlanto Axial Articulation." J. Amer. Osteopath. Ass. 63:28-32, September 1963.

Duerrigl, T. "[Technic of Measurement of the Sagittal Mobility of the Thoracic Spine. Preliminary Report]" Z. Rheumaforsch 20:125-29, April 1961. (Ger)

Durrigl, T. "[The Index of Sagittal Flexibility of the Spinal Column]" AIR 8:188-96, September 1965. (Pol)

Gamburtsev, V.A. "[A Goniometric Method for Static and Dynamic Function Tests of the Joints of the Extremities and of the Spinal Column]" Khirurgiia (Sofia) 13:1021-37, 1960. (Bul)

Israel, M. "A Quantitative Method of Estimating Flexion and Extension of the Spine." Milt. Med. 124:181-186, 1959.

Jirout, J. "The Mobility of the Cervical Spinal Cord Under Normal Conditions." Brit. J. Radiol. 32:744-51, November 1959.

Jirout, J. "[The Mobility of the Cervical Spinal Cord in the Normal Individual]" Cesk. Neurol. 23:158-166, 1960. (Czech)

Kojima, I. "[Dynamic Study of the Thoracolumbar Column and the Lumbar Vertebral Column Through Photo-Elastic Experiments]" J. Jap. Orthop. Ass. 37:921-35, February 1964. (Jap)

Lukas, R. "[Contribution on the Determination of the Degree of Rotation of Vertebral Bodies by Angle Measurement]" Zschr. Orthop. 91:286-296, 1959. (German)

Mura, Y. "[Dynamic Studies on the Cervico-Vertebral Column by Photo-Elastic Experiments]" J. Jap. Orthop. Ass. 35:245-61, June 1961. (Jap)

Nakagawa, T., et al. "[Scoliosis; Study on the Rotation of the Spine]" J. Jap. Orthop. Ass. 38:702-4, October 1964. (Jap)

Ogata, A. "[Radiographic Study of the Movement of the Cervical Vertebrae in Related Diseases]" J. Jap. Orthop. Ass. 38:646-648, 1964. (Jap)

Rossler, G. and Schmeiser, A. "[The Decrease of Mobility of the Cervical Spine Caused by Age]" Zschr. Alternforsch. 11:75-80, 1957. (German)

Rossler, G. and Schmeiser, A. "[Age Factor in the Participation of the Segments in the Course of Cervical Spine Movement]" Zschr. Alternforsch. 12:171-176, 1958. (German)

Sollmann, A.H. and Huber-Schoerry, L. "[Ballisto-Spinographic Measurements of the Vertebral Column]" Arch. Phys Ther (Lpz) 11:200-9, May-June 1959. (Ger)

Sollmann, A.H. "[Disturbed Spinal Kinematics]" Zbl Chir 85:1154-60, May 1960. (Ger)

Vossius, G. "[A So-Called "Inner" Regulation Center of Voluntary Movement]" Kybernetik 1:28-32, January 1961. (Ger)

Wasilev, W. "[Biomechanical Investigation of the Cervical Vertebrae]" Dokl Bolg Akad Nauk 17:593-6, 1964. (Ger)

Weisflog, G. "[Remarks on the Physiomechanics of the Spine]" Polski. Prezegl. Radiol. 21:141-158, 1957. (Pol)

Wigand, M.E. "[Electromyographic Measurement of the Reaction Time of Movement of the Head and Different Sound Stimuli]" Arch Ohr Nas Kehlkopfheilk 182:628-33, 9 December 1963. (Ger)

2. MECHANISMS OF INJURY

Ahlgren, P., and Mygind, T., "[Fracture in the Epistrophic Arch in Hanging without Fatal Outcome]", Fortshr Roentgenstr, 97:655-7, November, 1962. (German)

Compere, E., "The Mechanism of Injury and Orthopaedic Treatment of the Cervical Syndrome", Wiederherstellungschir Traum, 7:111-23, 1963. (Ger)

Eggleston, A.A., "An Osteopathic Appraisal of Biomechanical Stress in the Cervical and Upper Thoracic Areas. Physiologically Centered Differential Diagnosis", J Osteopath, 70:21-30, March, 1963.

Fratta, B. and Cazzato, A., "[Pathological Aspects of the Lumbar Spine in the Mechanical and Dynamic Stress of Parachute Jumping. Preliminary Note]", G Med Milit, 113:254-64, May-June, 1963. (Italian)

Gattuso, C., "[Further Considerations on the Physiopathology of the Cervical Spine in Wrestlers]", Sicilia Sanit, 15:453-8, July, 1962. (Italian)

Hunt, C.C. and Perl, E.R., "Spinal Reflex Mechanisms Concerned with Skeletal Muscle", Physiol Rev, 40:538-79, July, 1960.

Jaros, M. et al., "[Role of the Spine in Persons Lifting Weights]", Beitr Orthop Trauma, 12:653-5, October, 1965. (German)

Nicholas, J.A., Wilson, P.D. and Freiberger, R., "Pathological Fractures of the Spine. Etiology and Diagnosis. A Review of One Hundred and Five Cases", J Bone Joint Surg, 42-A:127-37, January, 1960.

Sudzilovskii, F.V. and Khromov, O.P.,"[On morphological changes in the cervical segment of the spine in subjects practicing wrestling]," Arkh. Anat. 44:66-71 Feb. 63 (Russian)

Toennis, D. "[New viewpoints on the pathogenesis of spinal cord lesions in injury of the spine]," Langenbeck Arch. Klin. Chir., 292:522-3 1959, (German)

Walker, A.E., "Anatomical factors related to pathogenesis of acute spine injuries. The neurosurgeon's viewpoint." J. Bone Joint Surg., 46:1806-10, December 64,

3. ANATOMY/RADIOLOGY

Aufdermaur, M., "[Pathologico-anatomical principles of the cervical spine syndrome]" Wiederherstellungschir Traum, 7:56-83, 1963 (German)

Badoux, D.M.,"A contribution to the study of the body axis in mammals with special reference to domesticated dog." Proc. Kon. Nederl. Akad Wet. [Biol Med] 68:374-90, 1965

Barr, M.M., "Neck and chest injuries: some techniques in casualty radiography," Radiography 27:183-7, Jun 61.

Beilin, L.G., "[On the technic of roentgenography of the spine in the lateral position]," Vestn. Rentgen. Radiol., 37:60-1, Nov.-Dec. 62, (Russian)

Bernaille, C., "[Contribution of radiology in the diagnosis of spinal injuries]," France Med., 26:197-209, April 63, (French)

Bigazzi, G. and Viviani, G., "[Radiological considerations on a case of cervical disco-ligamentous laceration]," Minerva Med., 51:1663-6, 5 May 60 (Italian)

Bonamini, F. et. al., "[Antero-posterior diameter of the cervical vertebral canal in the normal subject. Statistical findings and considerations]," Arch. Sci. Med., (Torino) 119:225-33, May 65, (Italian)

Borisevich, A.I., "[On some characteristics of growth and development of the spinal column in man in various definitive phases of differentiation]," Arkh. Anat., 48:59-63, Jun 65, (Russian)

Bugyi, B., "[On the age-related functional behavior of the cervical spine in the roentgen picture]," Z.Alternsforsch, 16:325-9, Oct. 63, (German)

Bugyi, B., "[Functional studies of the cervical spine]," Pol. Przegl. Radiol. 26:271-5, Jul-Aug. 62 (Polish)

Calvi, N., "[Radiographical findings on the cervical spine in patients of cranial injuries]," Arch Ortop., (Milano) 73:557-62, 1960 (Italian)

Coupe, C.W., "Cervico-dorsal region: lateral projection," Xray Techn., 33:256-7, Jan. 62

Delahaye, R.P. et. al., "[Value of a screening x-ray examination in jet pilots]," Rev. Med. Aero, (Paris) 3:49-52, Oct.-Nov. 64 (French)

Ekert, F., "[On the terminology of radiologic findings in the vertebral column]," Munchen Med. Wschr., 105:1881-5, 27 Sep. 63, (German)

Fischer, E., "[Roentgen injury of the spinal cord. Short survey of roentgen injuries of the central nervous system]," Ugeskr Laeg, 126:1386-70, 1 Oct. 64 (Danish)

Gavrin, A.G., et. al., "[An attachment for large-frame fluorography for the examination of the skull, paranasal sinuses and spine]," Vestn Rentgen Radiol., 40:57-8, Mar.-Apr. 65 (Russian)

Gros, C.M., Bloch, P. and Walter, J.P., "[Radiography of the entire spinal column in physiological position]," J Radiol Electrol, 41:254-7, May 60 (French)

Hinck, V.C., et. al., "Normal interpediculate distances (minimum and maximum) in children and adults," Amer J Roentgen, 97:141-53, May 66.

Holt, E.P., "Falacy of cervical discography. Report of 50 cases in normal subjects." JAMA, 188:799-801, 1 Jun 64.

Hromada, J., Pospisil, M., "[Anatomical and embryological observations on the spine]," Bratisl Lek Listy, 43:68-79, 31 Jan. 63, (Czechoslovakian)

Ishibashi, M., "[Electromyographic study on the function of back muscles in fracture of the spine]," Nagasaki Med J, 37:244-53, Sep. 62 (Japanese)

Jirout, J., "[Correlation of dynamic disorders of the cervical spine in the sagittal and frontal planes]," Cesk Neurol, 27:296-8, Sep 64 (Czechoslovakian)

John, J.R., and Littleton, J.T., "An evaluation of cinefluorographic examination of the cervical spine," Guthrie Clin Bull, 32:110-20, October 62.

Kettunen, K., "Dosage to the lens in radiography about the head and neck," Acta Opthal, (Kobenhavn) 43:235-9, 1965.

Kochs, J., "[Causes of the variable estimates of the functional capacity of the spine, and also, a contribution to the question of the subjectively experienced functional disorders in medicolegal practice]," Z Orthop, 97:153-63, May 63, (German)

Kozlowski, P., and Krol, M., "[Luschka's joints]," Pol Przegl Radiol, 23:267-75, Sept.-Oct. 59 (Polish)

Last, R.J., "Clinical anatomy in practice (II)," Brit J Oral Surg, 1:177-87, Apr. 64.

Lescure, R.J., "[Vertebral physiology of the neck]," Rhumatologie, 11:167-88, July-Aug.59 (French)

Likhachev, Iu.P., et. al., "[Injuries of the spinal cord in radiotherapy]," Med. Radiol, (Moskva) 8:27-33, Apr. 63, (Russian)

Lippert, H., and Lippert, E., "[Shape change and growth dynamics of the human vertebra]," Z Anat Entwicklungsgesch, 122:63-85, 1960, (German)

Matz, H., "[The absolute and relative number of muscle spindles in the deep neck muscles of chimpanzees]," Anat Anz, 113:19-21, 31 Jul. 63, (German)

Mazo, I.S., "[A method of roentgenography of the cervical vertebrae in lateral projection]," Vestn Rentgenol Radiol, 35:65, May-Jun. 60 (Russian)

Nadvornik, P., et. al., "[Clinical and anatomical correlations in injuries of the cervical spinal cord]," Rozhl Chir, 44:641-7, Sep. 65, (Czech.)

Oon, C.L., "Some sagittal measurements of the neck in normal adults," Brit J Radiol, 37:674-7, Sep. 64.

Penning, L., "[Radiological aspects in trauma of the cervical spine]," Neurochirurgie, 8:279-89, Jul.-Sep. 62, (French)

Penning, L. et. al., "[Origin, structure and function of meniscoid structures in the cervical vertebral joints]," Z Orthop, 98:1-14, Dec. 63 (German)

Raspe, R.,"[On the evaluation of total exposure roentgenograms of the spine from the surgical-orthopedic viewpoint. A survey]," Zbl Chir, 85:1903-11, 17 Sep. 60, (German)

Reinhardt, K., "[Anatomy and pathology of the small vertebral articulations in the roentgenogram]," Radiol Diagn, (Berlin) 4:665-700, 1963 (German)

Rometti, M., "[Radio-clinical aspects of cervical curvature disharmonies]," Rhumatologie, 18:27-30, Jan. 66, (French)

Scatliff, J.H., "Cinefluorographic evaluation of the soft tissues of the neck," New York J Med, 63:1174-6, 15 Apr. 63.

Schmitzer, G. et. al., "Contribution to the clinicoradiologic study of the cervical column. Congenital anomalies and malformations," Rumanian Med Rev, 19:51-61, Jul.-Sep. 65.

Seze, S de, et al., "[Anatomical, physiological and radiological factors influencing the cervical spine]," Rev. Prat, 14: 3197-215, 11 Oct. 64 (French)

Stilwell, D.L., "The vascular supply of vertebral structures. Gross anatomy: rabbit and monkey," Anat Rec, 135:169-83, Nov. 59.

Strain, R.E., "Cervical discography and electromyography in the diagnosis of lacerated or torn cervical disc," J Florida Med Ass, 49:734-9, Mar. 63.

Svoboda, M., "[Use of zonography in the examination of the spine]," Cesk Neurol, 29:20-4, Jan. 66, (Czechoslovakian)

Templeton, A.W., et. al., "The transverse processes of the cervical vertebral segment. A correlation of oblique roentgenograms with skeletonized material," Radiology, 82:912-5, May 64.

Toendury, G., "[The cervical spine, its development and changes during life]," Acta Orthop Belg, 25:602-26, Sept.-Oct. 59, (French)

Tokarowski, A., "[On the function of the deep muscles of the spine]," Chir Narzad Ruchu Ortop Pol, 30:525-6, 1965, (Polish)

Trotter, M., Broman, G.E., and Peterson, R.R., "Density of cervical vertebrae and comparison with densities of other bones," Amer J Phys Anthrop, 17:19-25, March 59.

Vargha, G., "[A new method for the demonstration of the spinous processes of the upper thoracic vertebrae in transthoracic oblique presentation]," Magy Radiol, 12:97-101, June 60, (Hungarian)

Wachtler, F., "[On lesions in the cervical section of the spinal cord after therapeutic radiation in the neck region]," Strahlentherapie, 119:97-103, Sep. 62, (German)

Wachtler, F., "[On damage to the cervical region of the spinal cord following roentgen irradiation]," Wien Z Nervenheilk, 21:203-22, 2 Jan. 64, (German)

Waterstradt, A., et. al., "X-ray cinematographic examinations of the spinal column," Med. Boehringer (Overseas) 3:65, 1964.

Zhukova, G.P., "[On features of the structure of projections in the spine and medulla oblongata]," Arkh Anat, 41:58-64, Jul. 61, (Russian)

Zunkeler, K.G., "[On variations in the spine. Comparative observations in man and animals]," Z Menschl Vereb Konstitutionsl, 36:431-68, 1963, (German)

4. EXPERIMENTAL STRENGTH/STRESS

Asmussen, E., "The weight-carrying function of the human spine," Acta Orthop Scand, 29:276-90, 1960.

Barwood, A.J., "The maintenance of correct ejection posture," Aerospace Med, 34:618-21, July 63.

Christ, W., "[On stress on the human spine in the use of agricultural tractors]," Med Welt, 5:227-31, 4 Feb. 61, (German)

Colachis, S.C. Jr., et. al., "A study of tractive forces and angle of pull on vertebral interspaces in the cervical spine," Arch Phys Med, 46:820-30, Dec. 65.

Devito, J.L., et. al., "Analysis of residual weight discriminatory ability and evoked cortical potentials following section of dorsa columns in monkeys," Indian J Physiol Pharmacol, 8:117-26, June 64.

Gooding, C.A., et. al., "Growth and development of the vertebral body in the presence and absence of normal stress," Amer J. Roentgen, 93:388-94, Feb. 65.

Gurvich, G.I. and Martynov, V.A., "[The effect of voluntary movements of the eyeballs on the electrical activity of human neck muscles]," Biull Eksp Biol Med, 54:12-4, Dec. 62, (Russian)

Hasbrook, A.H. and Earley, J.C., "Failure of rearward facing seat-backs and resulting injuries in a survivable transport accident," US Civil Aeromed Res Inst, 62-7:1-11, Apr. 62.

Hirsch, C. and Nachemson, A., "Clinical observations on the spine in ejected pilots," Rev Med Aero (Paris), 2:193-4, Dec. 61.

Hirsch, C. and Nachemson, A., "[Back injuries after catapult ejection]," Medd Flyg Navalmed. Namnd. 12:1-4, 1963 (Swiss)

Hirsch, C. and Nachemsson, A., "Clinical observations on the spines of ejected pilots," Industr Med Surg, 32:28-9, Jan. 63.

Hirsch, C., and Nachemson, A., "Clinical observations on the spine in ejected pilots," Aerospace Med, 34:629-32, Jul. 63.

Kubota, J. et. al., "[On calcium metabolism in the spine in repetitive bending load in rabbits]," J Jap Orthop Ass, 38:675-6, Oct. 64, (Japanese)

Laurell, L. and Nachemsson, A., "Some factors influencing spinal injuries in seat-ejected pilots,' Rev Med Aero, (Paris) 2:195-6, Dec. 61.

Laurell, L. and Nachemsson, A., "Some factors influencing spinal injuries in seat-ejected pilots, Industr Med Surg, 32:27-8, Jan. 63.

Laville, A. et. al., "[Electromygraphic study of the neck muscles during a precision task]," J Physiol, (Paris) 57:260, Jan-Feb. 65, (French)

Mettler, F.A. and Liss, H., "Functional recovery in primates after large subtotal spinal cord lesions," J Neuropath Exp Neurol, 18:509-16, Oct. 59.

Osetowska, E., "Observations on healing of post-traumatic lesions of the brain and spinal cord in rhesus monkeys," Acta Med Pol, 3:377-94, 1962.

Siau, "[The spine in aviators]," Rev Med Nancy, 85:318-27, Apr. 60, (French)

Steinmann, B., "[Traumatic transverse lesion of the spinal cord as an experimental physiological model]," Schweiz Med Wschr, 93:1045-5, 17 Aug. 63, (German)

Venable, J.R., et. al., "Stress fracture of the spinous process," JAMA 190:881-5, 7 Dec. 64.

Yamada, K., et. al., "[Experimental and clinical studies on the effect of long-term vibration on the spine]," J Jap Orthop Ass, 38:652-4, Oct. 64, (Japanese)

5. INJURIES/FRACTURES

Ahn, Y. "[Clinical observation on cervical syndrome]," Korean J Intern Med, 6:263-7, May 63, (Korean)

Albarosa, U., "[Fracture caused by occupational muscular traction (in shoveling worker) or the spinous apophysis of the last four cervical vertebrae]," Minerva Medicolegale, 80:32-4 Jan.-Apr. 60, (Italian)

von Albert, H. H., "[The cervical syndrome]," Munchen Med Wschr, 105:1045-60, 17 May 63, (German)

Anderson, W.F., "Cervical spine studies in older people," Rheumatism, 20:7-12, January 64.

Apshtein, Z.V., "[Physiologic evaluation of the spinal and abdominal muscles in patients with spinal injuries damaging the spinal cord]," Ortop Travm Protez, 25:54, Jun. 64, (Russian)

Arora, Y.R., "Closed cervical tracheal rupture," Brit J Clin Pract, 17:341-2, Jun. 63.

Ashkenazy, M., "Neck injuries," Med Rec Ann, (Houston) 55:169-70, Sep. 62.

Aufranc, O.E., et. al., "Unilateral rotary subluxation of C-3 on C-4," JAMA, 185:1031-5, 28 Sep. 63.

Axt, C., "[Does heavy work cause increased degenerative changes in the spine and locomotor apparatus?]," Z Orthop, 92:402-10, 1960 (German)

Babichenko, E.I., "[Transportation-splint in fractures of the cervical segment of the spine]," Ortop Travm Protez, 21:62-3, Jan 60, (Russian)

Baumgartner, W. "[Skiing and the spine]," Muenchen Med Wschr, 103:507-9, 10 Mar. 61, (German)

Becker, T., "[Heavy labor and degenerative spinal changes]," Deutsch Gesundh, 14:1241-4, 2 July 59, (German)

Behrman, S.J., "Fetal cervical hyperextension," Clin Obstet Gynec., 5:1018-30, Dec. 62.

Beks, J.W, Oen, T.S., "[Cervical trauma. Posterior operation with fusion]," Neurochirurgie, 8:327-8, Jul.-Sep. 62, (French)

Belenger, M., and Toussaint, J., "[Injuries of the cervical spine]," Acta Orthop Belg, 29:522-30, May-Jun. 63, (French)

Belis, V., et. al., "[Isolated direct fracture of the atlas]," Ann Med Leg, (Paris) 45:536-9, Nov.-Dec. 65,(French)

Benassy, J., "[Diagnosis and treatment of traumatic lesions of the cervical spine]," Rev Prat, 13:1529-48, 1 May 63, (French)

Bengui, A., "[Cervico-brachial neuralgia due to cervical arthrosis after a skiing accident. (Clinical and radiological recovery)]," Rev Rhum, 27:274-6, July-Aug. 60, (French)

Biemond, A., "[Contusion of the posterior cervical muscle]," Nederl T Geneesk, 108:1333-5, 4 Jul. 64, (Dutch)

Billig, H.E., "Conservative management of neck injuries," Clin Orthop, 24:68-82, 1962.

Bochenek, M., et. al., "[Fracture, Dislocation and Contusion of the Cervical Spine]," Chir. Narzod. Ruchu Ortop Pol, 28:799-800, 1963, (Polish)

Boehler, J., "[Is operative fixation of cervical spine injuries necessary?]," Langenbeck Arch Klin Chir, 292:529-33, 1959, (German)

Boeni, A., "[Physical therapy of traumatic spinal changes]," Z Unfallmed Berufskr, 52:122-33, 15 June 59,(German)

Bonnal, J., "[The post-concussion syndrome of cranio-cervical injuries]," Rev Med Liege, 20:495-9, 15 Sep. 65, (French)

Braaf, M.M. and Rosner, S., "Meniere-like syndrome following whiplash injury of the neck," J Trauma, 2:494-501, Sep. 62.

Braaf, M.M., and Rosner, S., "Headache following neck injuries," Headache, 2:153-9, Oct. 62.

Bradford, F.K., "Injuries to the spinal cord," J Arkansas Med Soc, 56:106-10, Aug. 59.

Bryk, V.E., "[Combined treatment of acute trauma of the cervical spine and the spinal cord]," Vop Neirooftal, 27:10-3, Mar.-Apr. 63, (Russian)

Buerkle De La Camp, H., "[Spinal injuries in motorists]," Klin Med, (Wein) 14:505-19, Nov. 59, (German)

Buerkle De La Camp, H., "[On the therapy of cervical spine luxations]," Langenbeck Arch Klin Chir, 292:514-22, 1959, (German)

Callens, J.,"[Fractures of the spine]," J Sci Med Lille, 81:226-35, Apr 63, (French)

Campanacci, M., "[Vertebral fractures (revision of 707 cases treated for recent traumatic lesions). II. Cervical fractures (97 observations)]," Chir Organi Mov, 52:454-65, 1964 (Italian)

Cathie, A.G., "The cervicothoracic area: some clinical and practical considerations," J. Amer Osteopath Ass., 59:513-9, Mar. 60.

Chrisman, O.D., et. al., "Lateral-Flexion neck injuries in athletic competition," JAMA, 192:613-615, 1965.

Christ, W., "[On the problem of expert testimony of cervical vertebral injuries with reference to congenital anomalies]," Mschr Unfallheilk, 62:379-83, Oct. 59 (German)

Cloward, R.B., "Delayed traumatic dislocation of the cervical spine," Hawaii Med J, 20:344-9, Mar.-Apr. 61.

Cloward, R.B., "Surgical treatment of traumatic cervical spine syndromes," Wiederberstellungschir Traum, 7:148-85, 1963.

Comoretto, R., "[Closed trauma of the cervico-thoracic region with fracture of the trachea (clinical case)]," Ann Laring, 63:612-9, 1964, (Italian)

Connolly, R.C., "Delayed spinal cord lesions following injury," Riv Pat Nerv Ment, 86:225-9, Apr. 65.

Cook, J.B., "The relationship of spinal cord damage to cervical spinal injury," Proc Roy Soc Med, 52:799-801, Oct. 59.

Crue, B.L. and Mabie, P.D., "Conservative treatment with halter traction in acute cervical trauma," Western J Surg, 68:176-81, May-June 60.

Crue, B.L., et. al., "The importance of flexion in cervical halter traction," Bull Los Angeles Neurol Soc, 30:95-8, Jun 65.

Czalbowska, I., "[Notes on the treatment of Injuries of the Cervical spine]," Chir Narzod Ruchu Ortop Pol, 28:793-4, 1963. (Polish)

Dagradi, A., et. al., "[Grave "whiplash lesions]," Ann Ital Chir, 41:73-82, 1964, (Italian)

Dalle Ore, G., et. al., "[Indications and results of Cloward's intervention in lesions of the cervical column]," Minerva Neurochir, 8:111-2, Jul.-Sep. 64, (Italian)

Decoulx, P, Razemon, J.P. and Ducloux, M., "[Fractures of the cervical spone without neurological complications. Therapeutic indications]," Lille Chir, 17:159-71, Jul.-Oct. 62,(French)

Delahaye, R.P., et. al., "[The problems raised by the existence of congenital anamolies of the spine in high-speed performance aviation]," Rev Med Aero, (Paris), 4:31-4, May-Jun. 65, (French)

Demuth, W.E., "Soft tissue injuries of the neck," Med Times, 90:611-7, Jun. 62.

Denicki, P., et. al., "[Observations on Injuries of the Cervical Spine]," Chir. Narzod Ruchu Ortop Pol, 28:809-812, 1963, (Polish)

Dick, H., "Some lesions of the cervical spine," J Coll Radiol Aust, 6:142-8, Dec. 62.

Ducloux, M., "[Injuries of the cervical spine]," Lille Med, 8:Suppl 1061-3, 1963, (French)

Dyde, J.A., "Chronic atlanto-axial dislocation due to separate odontoid process," Guy Hosp Rep, 112:113-26, 1963.

Ebel, A., et.al., "Severe cervical spine injury without myelopathy," Proc Ann Clin Spinal Cord Inj Conf, 13:59-64, 1964.

Evans, D.C., "Cervical injuries," Proc Mine Med Officers Ass., 41:81-8, Jan.-Feb. 62.

Fanti, A. and Trzebicki, J.,"[Neurologic manifestations in fractures of the spinous processes of the cervical vertebrae (according to observations on 2 cases)]," Pol Tyg Lek, 15:432-4, 21 Mar. 60, (Polish)

Fenner, H.A., "Football injuries and helmet design," GP, 30:106-13, Oct. 64.

Fiume, M. and Salvi, V., "[Traumatic lesions of the first 2 cervical vertebrae. (Presentation of 4 cases)]," Minerva Ortop, 14:259-64, May 63, (Italian)

Fiume, M. and Salvi, V., "[Considerations on fractures and dislocations of the cervical spine]," Lille Chir, 17:181-94, Jul.-Oct. 62, (French)

Forsyth, H.F., "Neck injuries in children," N Carolina Med J, 22:122-5, Mar. 61.

Galibert, P., "[A method of treatment of dislocations of the cervical spine complicated by spinal cord or radicular lesions]," Lille Chir, 17:172-80, Jul.-Oct. 62, (French)

Gelehrter, G., and Vittali, H.P. "[Forms of injuries of the cervical spine with the exception of the cranial joints]," Arch Orthop Unfallchir, 52:287-310, 1960, (German)

Gelehrter, G., "Differential diagnosis of cervical spine injuries in childhood]," Fortschr Roentgenstr, 99:506-17, Oct. 63 (German)

German, D.G., "[Changes in the nerve cells of the pia mater of the spinal cord in closed injuries]," Zdravookhranenie, (Kishinev) 6:37-40, May-Jun. 63, (Russian)

Gheewala, M.N., et. al., "Enlarged transverse process of atlas. A case report," J Postgrad Med, 10:58-62, Apr. 64.

Golovanov, V.D., "[The surgical treatment of spinal and spinalcord injuries]," Khirurgiia, (Mosk) 36:17-23, June 60, (Russian).

Goncalves, D.C., "[Treatment of luxations and fractures of the cervical spine]," Rev Bras Cir, 38:302-12, Oct. 59, (Por).

Grismer, J.T., et al., "Occlusion of the internal carotid artery secondary to closed cervical trauma," Minnesota Med, 47:959-61, Aug. 64.

Hampton, G. and Cline, P.D., "Management of cervical fracture with nerve root involvement," J Amer Phys Ther Ass, 43:513-5, Jul. 63.

Hackett, G.S., "Prolotherapy in whiplash and low back pain," Postgrad Med, 27:214-9, Feb. 60.

Hancevic, J., "[Contribution to the problem of extension therapy in fractures of the cervical vertebrae]," Chirurg, 33:550-1, Dec. 62, (German).

Hartung, J., "[An operation on the cervical column in a patient with multiple injuries]," Cah Anesth, 13:871-4, Nov. 65, (French).

Herzberger, E.E., Kendschi, L.G., Bear, N.E., and Chandler, A., "Treatment of cervical disc disease and cervical spine injury by anterior interbody fusion. A report on early results in 72 cases," Zbl Neurochir, 23:215-27, 1962.

Hillier, W.F., "Whip-lash injury: fact or fiction," W. Virginia Med J, 56:156-9, May 60.

Hodgson, A.R., "An approach to the cervical spine (C-3 to C-7)," Clin Orthop, 39:129-34, Mar-Apr 65.

Hohenwald, H., "[Vocal cord hemorrhage in neck trauma]," Z Aerzti Fortbild, (Jena) 57:1063-4, 1 Oct. 63, (German).

Houck, W.S., et al., "Occlusion of the internal carotid artery in the neck secondary to closed trauma to the head and neck: a report of two cases," Ann Surg, 159:219-21, Feb. 64.

Huebner, A., "[Contusion of the spinal cord as a cause of death]," Mschr Unfallheilk , 63:67-9, Feb. 60, (German).

Hughes, J.T. and Brownell, B., "Spinal-cord damage from hyper-extension injury in cervical spondylosis," Lancet, 1:687-90, 30 Mar. 63.

Humphries, S.V., "Fracture-dislocation of the spine with paraplegia," J Int Coll Surg, 35:602-4, May 61.

Hunkele, E., et al., "A patient with fractured cervical vertebrae," Amer J Nurs, 65:82-4, Sep. 65.

Jelinkova, L. and Keplova, S., "[Spine fractures in childhood]," Acta Chir Orthop Traum Cech, 27:348-53, Aug. 60, (Cz).

Jirout, J. and Kunc, A., "Traumatic herniation of the thoracic intervertebral disc," Acta Neurochir, (Wien) 8:88-93, 7 Apr. 60.

Junghanns, H., "[Sequels of trauma of the normal and of the previously injured spine]," A Unfallmed Berufskr, 52:101-22, June 59, (German).

Kahn, E.A., et al., "Acute injuries of the cervical spine," Postgrad Med, 39:37-44, Jan. 66.

Kazkakevicius, J., "[Compression fractures and fracture-dislocations of the spine]," Sveik Apsaug, 7:12-7, Jun. 62, (Lith).

Keating, S.R., "The treatment of fracture dislocations of the spine with cord involvement," E Afr Med J, 37:619-20, Sep. 60.

Khaidudov, L., Khadzhistamov, B., Namichev, Ia., Dishliev, B., Chervenivanov, G., Punchev, G., Khadzhiev, D., and Minchev, M., "[Traumatic injuries of the spinal column and of the spinal cord]," Khirurgiia (Sofia) 12:710-8, 1959, (Bul).

Klaus, E.J. and Andresen, R., "[On a fatal injury of the cervical spine after diving]," Deutsch Med Wschr, 85:1309-11, July 60. (Ger)

Knoblock, J. and Konopasek, J., "[Effect of sequelae of vertebral fractures on work capacity]," Acta Chir Orthop Traum Cech, 27:405-16, Oct. 60, (Cz).

Landrgot, B., Polak, O., and Suchan, J., "[Late sequelae of injuries to the cervical spine]," Bratisl Lek Listy, 43:166-70, 15 Feb. 63, (Cz).

Landrgot, B., et al., "[Injuries of the cervical spine]," Acta Chir Orthop Traum Cech, 31:457-64, Oct. 64, (Cz).

Lazorthes, G., Espagno, J., Campan, L., and Van Hong, N., "[Psychic disorders in the course of cervical vertebro-spinal cord injuries]," Neurochirurgie, 8:330-2, Jul.-Sep. 62, (French).

Lazzari, E., et al., "[Posterior wall injury and spinal cord lesions in vertebral fractures and lesions. Personal considerations and statistics]," Minerva Radiol, 9:176-81, May 64, (Italian).

Lemmen, L.J. and Laing, P.G., "Fracture of the cervical spine in patients with rheumatoid arthritis," J Neurosurg, 16:542-50, Sep. 59.

Lithander, B., "[Injury to the cervical spinal cord through diving into shallow water]," Lakartidningen, 62:592-6, 24 Feb. 65, (Swedish).

Lore, J.M., Jr., "Head and neck surgery," Surg Gynec Obstet, 118:117-8, Jan. 64.

Lukanov, A., "[Our experience with the treatment of spinal fractures]," Khirurgiia, (Sofia) 12:723-6, 1959 (Bul).

Mar'in, S.D., "[Ligation of the vertebral artery in injury of the neck]," Khirurgiia, (Mosk) 35:108-9, Sep. 59, (Russian).

Martin, G.M., "Sprains, strains, and whiplash injuries," Phys Ther Rev, 39:808-13, Dec. 59.

Martin, M.A., "Nursing care in cervical cord injury," Amer J Nurs, 63:60-6, Mar. 63.

Maul, R., "Cervical strain," Phys Ther Rev, 39:814-5, Dec. 59.

McKeever, D.C., "Nonunion of first thoracic spinous process: case report," Clin Orthop, 16:302-3, 1960.

Melvin, W.J., "The emergency treatment of diving accident," Appl Ther, 7:459-62, Jun. 65.

Mikity, V.G., et al., "Intervertebral disk calcification in children," Amer J Roentgen, 95:200-2, Sep. 65.

Milanowshka, K., et al., "[Notes on its possibilities and results of late rehabilitation of patients with fractures of the cervical spine]," Chir Narzad Ruchu Ortop Pal, 28:805-806, 1963, (Pol).

Miwa, T., et al., "[On the syndrome of acute central cervical spinal cord injury]," Brain Nerve, (Tokyo) 15:1073-9, Nov. 63, (Japanese).

Mokhort, V.A., "[Findings on the restoration of bladder function in experimental spinal cord innury]," Vop Neirokhir, 27:38-41, Jul.-Aug. 63, (Russian).

Munchow, H., et al., "[On the question of transitional vertebra formation in the occipito-cervical region]," Psychiat Neurol, (Basel) 149:241-64, 1965, (German).

Munro, D., "Broken necks. A study of their present-day mortality and other pertinent data," Conn Med, 24:8-16, Jan. 60.

Murphey, F. and Simmons, J.C., "Initial management of athletic injuries to the head and neck," Amer J Surg, 98:379-83, Sep. 59.

Muschio, R. and Zanuso, F., "[Further contribution to the treatment of dislocations of the cervical spine]," Arch Ortop, (Milano) 74:155-9, 1961, (Italian).

Narodovol'tseva, S.E., "[Remote results of early surgical treatment of closed injury to the spine and spinal cord]," Vop Neirokhir, 27:28-30, Nov.-Dec. 63, (Russian).

Nikitin, M.N., "[One-stage fixation of cervical vertebral dislocations]," Ortop Travm Protez, 24:42-7, Aug. 63, (Russian).

Noodt, H., "[Experiences with 30 fractures of the cervical vertebrae]," Mschr Unfallheilk, 67:18-25, Jan. 64, (German).

Nott, M.G., "Spinal fracture dislocation without dislocation," Lancet, 1:1217-8, 28 May 66.

Novotny, S. and Uher, J., "[Occupational trauma by pneumatic tools as a cause of spinal lesions]," Pracov Lek, 11:511-5, Dec. 59, (Cz).

Nurick, S., "Vertebral artery compression due to recurrent subluxation of a cervical vertebra," Guy Hosp Rep, 112:152-8, 1963.

Nyquist, R.H., "Mortality in spinal cord injuries. Follow-up reprot," Calif Med, 103:417-9, Dec. 65.

Oblonczek, G., "[The freguency of cervical spine injury in motorcycle accidents]," Chir Narzad Ruchu Ortop Pol, 28:803-804, 1963, (Polish).

Oldack, M., "Backs and brains; lifting,"Amer Assn Industr Nurses J, 14:17, Mar. 66.

Pearce, L.S., et al., "Spinal cord injury: statistical review of 35 autopsy cases," Proc Ann Clin Spinal Cord Inj Conf, 13:88-93, 1964.

Pertuiset, B., "[Closed traumatisms of the cervical spine; the immediate medullary problem]," Ann Chir, (Par) 13:917-23, Aug. 59, (French).

Pichler, E., "[Expert evaluation of cervical migraine]," Wien Med Wschr, 113:117-9, 2 Feb. 63, (German).

Pizio, Z., "[Type of cervical spine injuries associated with head injuries]," Chir Narzad Ruchu Ortop Pol, 28:801-2, 1963, (Polish).

Pizon, P., "[Statistical analysis of the sequelae of minor traumatisms of the cervical spinal column]," Presse Med, 71:278-80, 2 Feb. 63, (French).

Powirtowski, H., et al., "[Clinical observations on the treatment of traumatic paralysis of the cervical spine]," Chir Narzod Ruchu Ortop Pol, 28:823-831, 1963, (Polish).

Probst, J., "[Injuries of the cervical vertebrai difficult to diagnose and manifested by the cervical vertebrae syndrome]," Med Klin, 58:793-9, 10 May 63, (German).

Quigley, T.B., "Simple first aid traction splint for cervical spine injuries," Med Bull US Army Europe, 20:51-2, Feb. 63.

Ramadier, J.O., and Perraguln, J.J. "[Fractures and dislocations of the cervical spine]," Ann Chir, (Par) 13:901-16, Aug. 59, (French).

Razemon, J.P., "[Undiagnosed vertebral compression and pathogical fractures]," Rev Prat, 13:1573-84, 1 May 63, (French).

Rich, W.G., "Three cases of subluxation in the cervical region," Med J Aust, 1:524-5, 4 Apr. 64.

Richter, R.W. and Behnke, A.R., "Spinal cord injury following a Scuba dive to a depth of 350 feet," US Armed Forces Med J, 10:1227-34, Oct. 59.

Rivera-Williams, C., "[Atlanto-axial dislocation in childhood. Presentation of 5 cases. Experience of the Hospital Infantil de Mexico]," Bol Med Hosp Infant Mex, 20:79-96, Jan.-Feb. 63, (Spanish).

Roaf, R., "Spinal injuries," Burma Med J, 8:139-143, 1960.

Robertson, M.E., "A patient with back injury," Canad Nurse, 61:641-7, Aug. 65.

Rocco, B., "[Traumatic lesions of the neck]," Riv Infort Mal Prof, 51:1108-28, Nov.-Dec. 64, (Italian).

Roche, L., Colin, M., Rougemont, J. de, Vedrinne, J., Vitani, C., and Tommasi, M., "[Traumatic lesions of the cervical spine and involvement of the vertebral artery]," Lyon Med, 210:101-10, 21 Jul. 63, (French).

Roche, L., Colin, M., Rougemont, J. de, Vedrinne, J., Vitani, C., Tommasi, M., "[Traumatic lesions of the cervical spine and involvement of the vertebral artery. Responsibility of a medical examination]," Ann Med Leg, (Paris) 43:232-5, May-June 63, (French).

Romer, K.H. and Wolff, F., "[On spinal injuries due to mistreatment in very small children]," Arch Orthop Unfallchir, 55:203-11, 1963, (German).

Rosendahl, B., "[Manipulation treatment of the cervical and thoracic spine]," Nord Med, 69:681-4, 6 June 63, (Swedish).

Rosenzweig, N., "A new approach to the management of acute dislocations and fracture-dislocations of the cervical spine," S Afr Med J, 38:892-4, 7 Nov. 64.

Ross, E., "[On the variants of the cervical and lumbar spine displacement phenomenon]," Fortsehr Roentgenstr, 100:242-53, Feb. 64, (German).

Rugiero, G., "[On a case of anterior subluxation of the immediate postoperative period]," Gazz Int Med Chir, 69:2440-2, 31 Dec. 64. (Italian).

Safer, L.A., "Head and neck injuries," Pacif Med Surg, 73:169-71, May-Jun. 65.

Savastano, A.A. and Pierik, J.G., "Traumatic compression fractures of the dorsolumbar portion of the spine," J Int Coll Surg, 34:93-101, July 60.

Savchenko, E.A., "[On vertical fractures of the cervical vertebrae]," Ortop Travm Protez, 21:45-8, Feb. 60, (Russian).

Schechter, M.M., et al., "Special procedures in the management of traumatic lesions of the head and neck," Radiol Clin N Amer, 4:53-74, Apr. 66.

Schinbein, J.E., "Athletic injuries," Med Serv J Canada, 19:881-7, Dec. 63.

Schlesinger, E.B., "Treatment of head and neck pain associated with disorders of the neck and cervical spine," Mod Treatm, 1:1404-11, Nov. 64.

Schmauss, A.K., "[On the expert examination of spinal injuries and their sequelae]," Deutsch Gesundh, 14:1414-9, 30 July 59, (German).

Silberstein, C.E., "The evolution of degenerative changes in the cervical spine and an investigation into the 'joints of Luschka'," Clin Orthop, 40:184-204, May-June 65.

Silvernail, W.K. and Collins, J.M. "New traction device for transportation of patients with fracture-dislocation of cervical spine," US Armed Forces Med J, 10:904-7, Aug. 59.

Smolik, A., "[Therapeutic management of cervical spine injuries with paralysis]," Chir Narzod Ruchu Ortop Pol, 28:795-792, 1963, (Polish).

Stoianov, P. and Milenkov, K., "[Fracture of the spinal processes C7 and D1 as an occupational disease]," Khirurgiia, (Sofia) 13:989-90, 1960, (Bul).

Stringa, G., "[Traumatic lesions of the cervical spine (statistics and classification)]," Arch Putti, 20:53-77, 1965, (Italian).

Taubert, D., "[The after-treatment of the accidentally injured from modern viewpoints. Part 2. Fractures, injuries of the skull and the spinal column]," Deutsch Gesundh, 14:2109-14, 12 Nov. 59, (German).

Tessore, C., "[Treatment of fractures of the cervical spine]," Chir Narzod Ruchu Ortop Pol, 28:779-783, 1963, (Polish).

Tippett, R., "Postoperative treatment for fracture dislocation of six cervical vertebra," Phys Ther Rev, 41:643-4, Sep. 61.

Tonnis, W., et al., "[Brain and nerve injuries in children and adolescents]," Langenbeck Arch Klin Chir, 304:562-83, 5 Nov. 63, (German).

Torma, T., "[Emergency measures in brain and spinal cord injuries]," Suom Laak, 18:747-55, May 63, (Fin).

Tormasi, I. and Zimanyi, L., "[A rare case of multiple vertebral dislocations]," Mary Radiol, 13:111-4, Mar. 61, (Hun).

Vaisvila, Z., "[Results of the treatment of closed complicated spinal fractures according to data of the Siauliani Republican Hospital in 1952-1960]," Sveik Apsaug, 8:22-5, Dec. 63, (Lith).

Verjaal, A., "[History of the broken neck]," Nederl T Geneesk, 108:1149-50, 6 Jun. 64, (Dut).

Virgin, W.J., "Fracture of the spine with paraplegia," J Christ Med Ass India, 35:190-5, May 60.

Virozub, I.D., "[On the treatment of spinal injuries with injury of the spinal cord during the acute period]," Vop Neirokhir, 27:28-31, Jul.-Aug. 63, (Russian).

Vitulo, R.A., "[Clincial resolution of fractures of the spinal column]," Sem Med, (B Air) 121:253-4, Jul. 62, (Spanish).

Vlahovitch, B., Bouchard, C., and Tournoux, P., "[High traumatic spinal cord lesion. Congenital C2-C3 fusion]," Neurochirurgie, 9:117-20, Jan.-Mar. 63, (French).

Wassiley, W., "[On the problem of so-called vertebral joints]," Dokl Bolg Akad Nauk, 18:695-8, 1965, (German).

Watson, D., et al., "Cervical facets locked unilaterally," Med J Aust, 1:444-6, 21 Mar. 64.

Weber, E., "[On the operative reposition of cervical spine luxations]," Langenbeck Arch Klin Chir, 292:523-5, 1959, (German).

Wegener, H., "[Fractures and luxations of the cervical spine without neurological involvement]," Fortschr Roentgenstr, 97:751-6, Dec. 62, (German).

Wegener, H., "[A vertical fracture of the cervical spine with almost uncomplicated survival]," Fortschr Roentgenstr, 97:658-60, Nov. 62. (German).

Wenker, H., "[First aid in cerebrocranial injuries and damage to the spinal cord]," Landarzt, 40:181-5, 20 Feb. 64, (German).

Wertheimer, P., et al., "[Apropos of the treatment of closed injuries of the spinal cord]," Ann Chir, 18:169-74, Feb. 64., (French).

Wilson, C.B., "The role of anterior interbody fusion in acute injuries of the cervical spine," J Kentucky Med Ass, 63:260-4, Apr. 65.

Wolff, F., "[Incised wound of the neck following an unusual traffic accident]," Deutsch Z Ges Gerichtl Med, 56:14-9, 1965, (German).

Wu, S.Y. Tuan, F.S., and Li, H.J., "[Cause of high fever after cervical spinal injury and its cure]," Zhong Waike Z, 10:790-2, Dec. 62, (Ch).

Wyss, V., "[Greco-Roman wrestling. On the cervical spine of wrestlers]," Minerva Ortop, 10:558-69, Sep. 59, (Italian).

Young, W.H. and Masterson, J.H., "Psychology, organicity, and 'whiplash'," Southern Med J, 55:689-93, Jul. 62.

Zarling, M.E., "Vertebra column injuries," J Lancet, 86:281-4, Jun. 66.